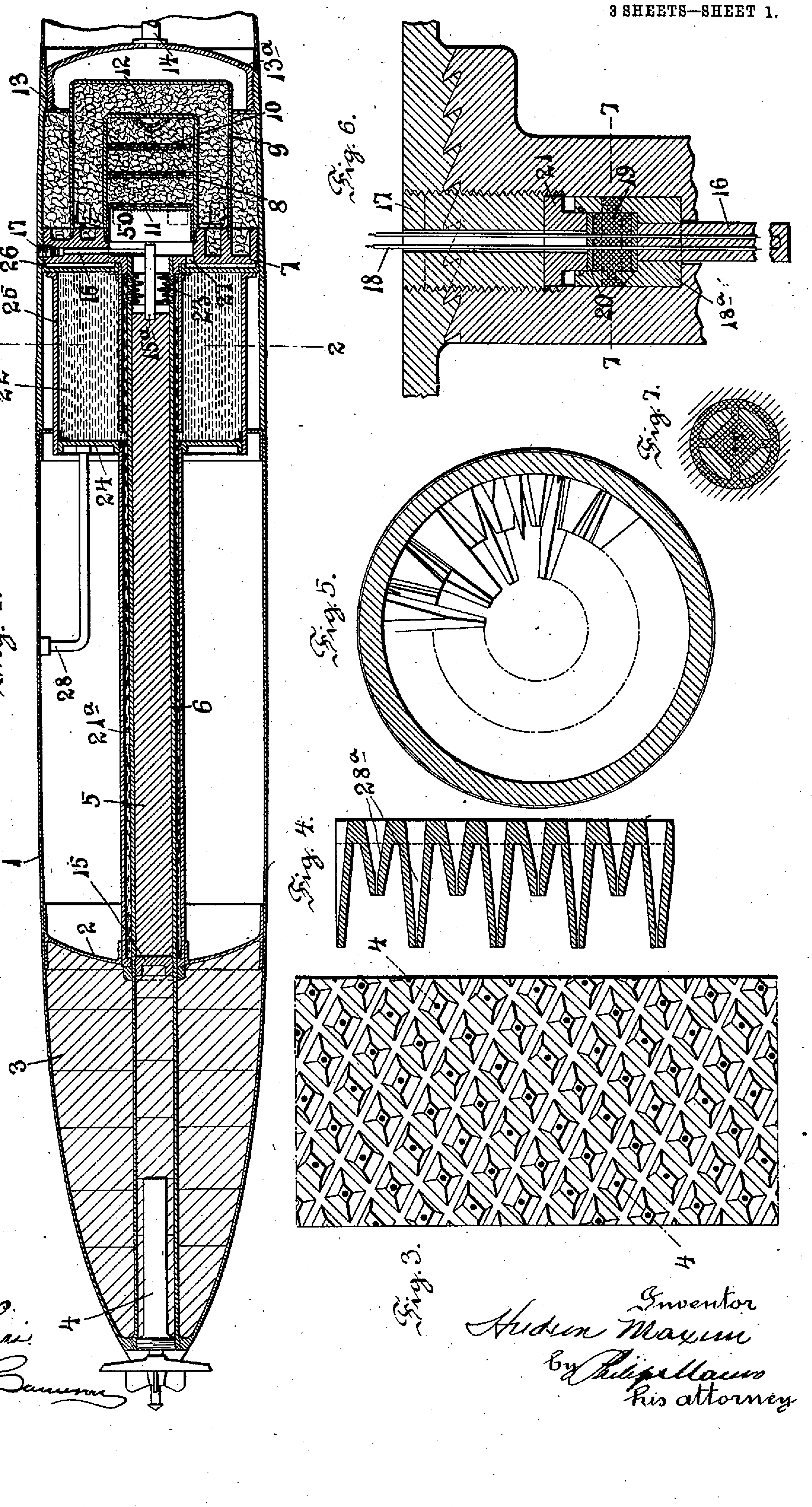
H. MAXIM.

PROCESS OF PRODUCING MOTIVE FLUID.

APPLICATION FILED MAR. 23, 1899. RENEWED MAY 18, 1904.

931,135. Patented Aug. 17, 1909.

3 SHEETS—SHEET 1.



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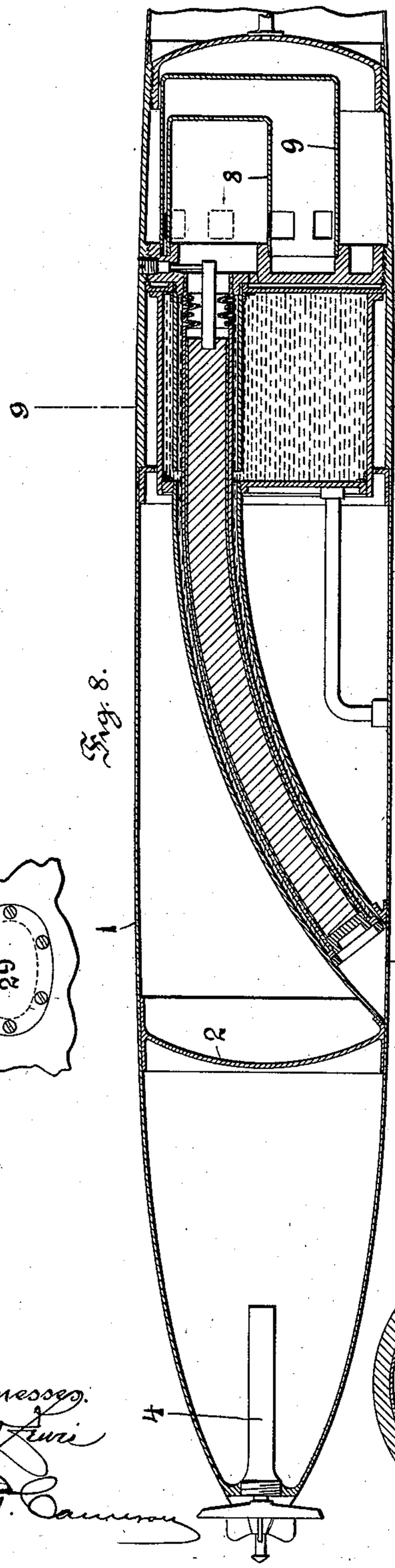

Fig. 8.

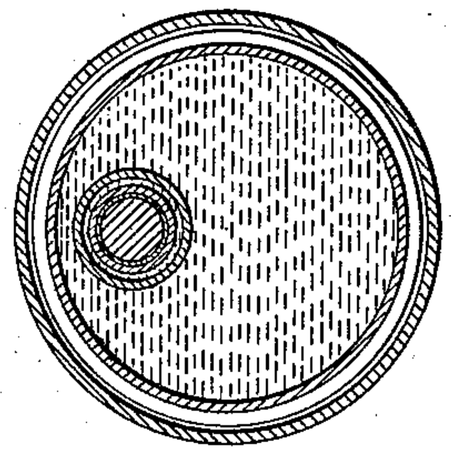

Fig. 9.

Fig. 10.

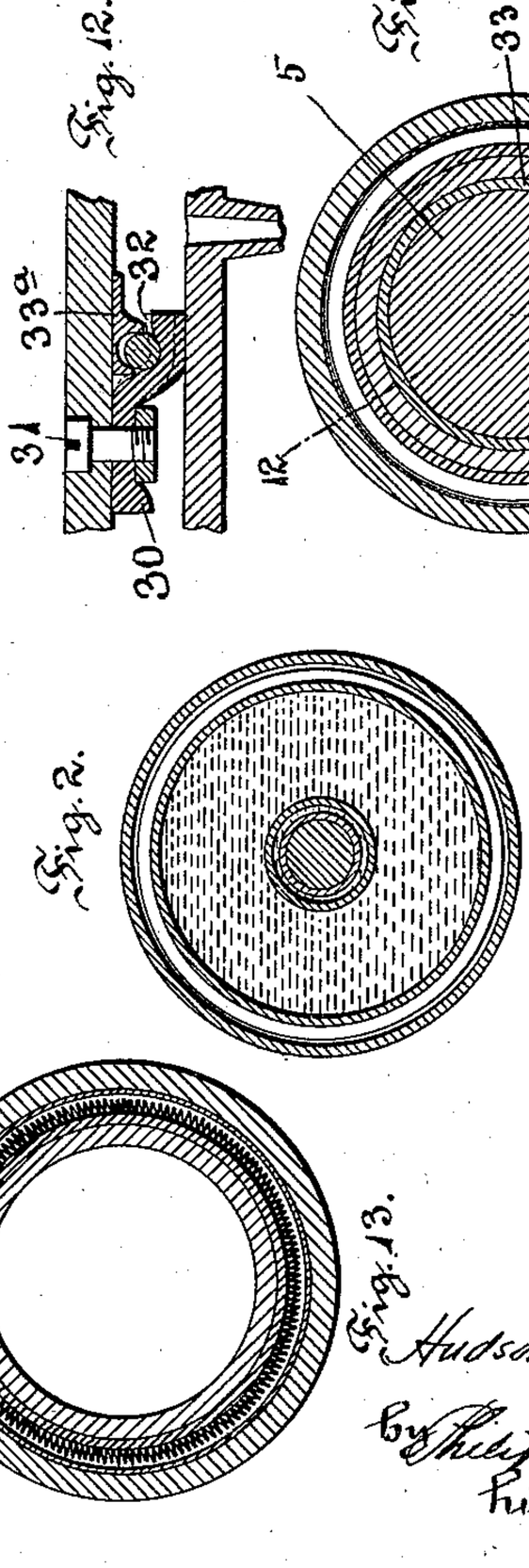

Fig. 12.

Fig. 11.

Fig. 2.

Fig. 13.

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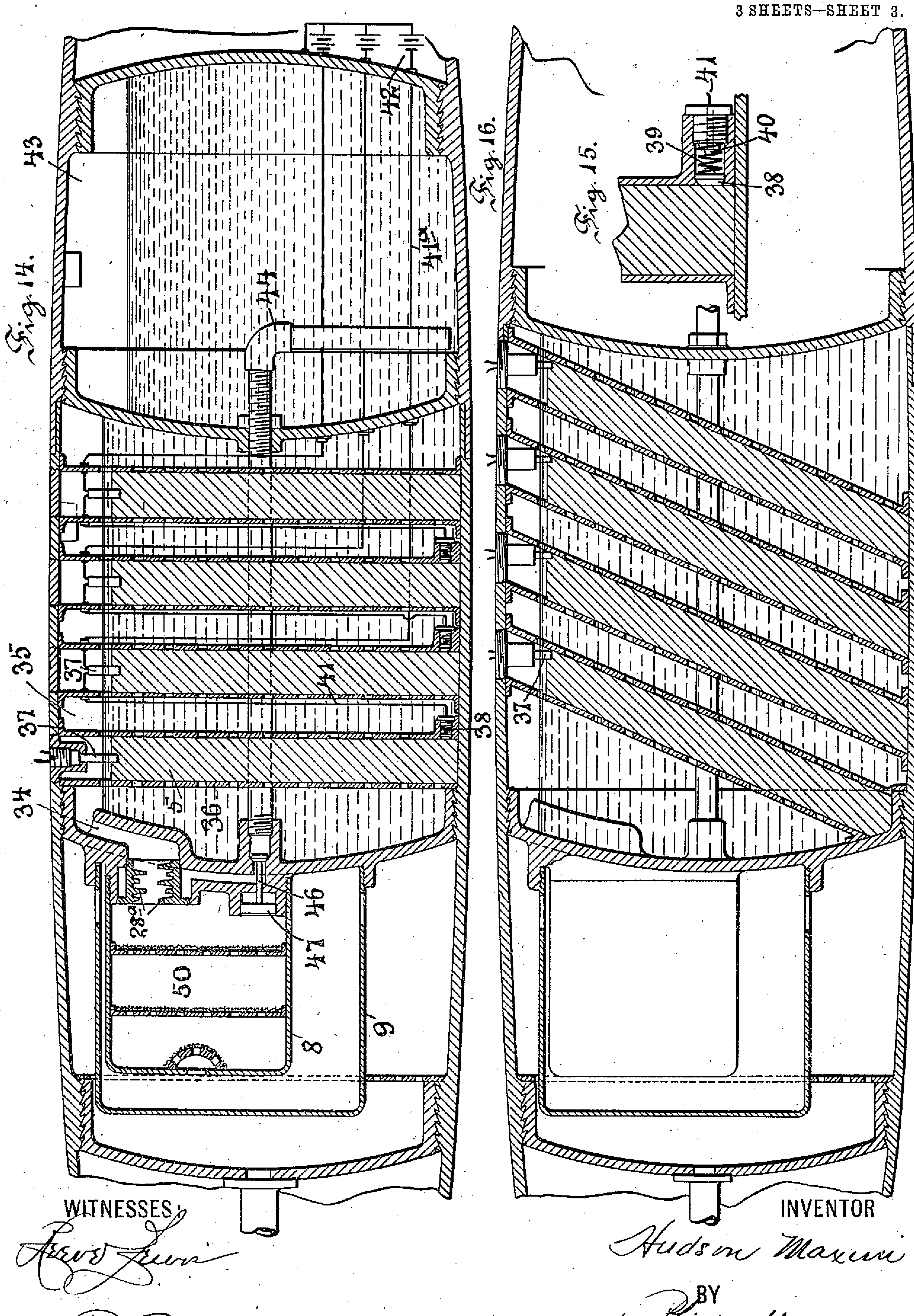
3 SHEETS—SHEET 3.



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PROCESS OF PRODUCING MOTIVE FLUID.

No. 931,135. Specification of Letters Patent. Patented Aug. 17, 1909.

Application filed March 23, 1899, Serial No. 710,192. Renewed May 18, 1904. Serial No. 208,561.

To all whom it may concern:

Be it known that I, HUDSON MAXIM, resident of the city and State of New York, have invented new and useful Processes of Producing Motive Fluid, which are fully set forth in the following specification.

The present invention relates to an improved process for producing motive fluid, for use mainly for the more rapid propulsion than heretofore of self-propelled torpedoes, torpedo boats, and light naval and other launches, though it is also applicable for other purposes.

The invention has for its object mainly to provide a process by which the products of combustion of a nitro-compound or other compound capable of supporting its own combustion (hereinafter referred to as a self-combusting body) may be confined, controlled and utilized for producing a motive fluid, for use in actuating a motor or otherwise (as in jet propulsion), and by which the great heat of the products of combustion is utilized to evaporate a liquid, or to heat a gas or vapor for use independently or in connection with the said products of combustion for actuating a motor, or as a propelling agent.

The invention also has for its object to provide for the generation and supply of a larger volume of motor fluid and at a much higher pressure than has heretofore been practicable without increasing the weight or size of present automobile torpedoes, when the invention is employed in their propulsion, to the end that the motor or other propelling means may be operated for a much longer period of time, and the torpedo driven to a greater distance and at a much increased speed.

Another desirable result of the employment of the present invention is that the shell of the torpedo, and especially that part which has heretofore been employed as the compressed air flask, may be greatly lightened, thereby enabling the torpedo to carry a greatly increased charge of high explosives.

With these objects in view the invention, generally stated, consists in the process of producing a motive fluid which consists in continuously burning a body capable of sustaining its own combustion, as a colloidal nitro-compound, and continuously forcing a liquid, as water, into the products of combustion by the action of the products of combustion themselves, and thereby utilizing the heat of the products of combustion to vaporize the liquid, while the latter serves to reduce the temperature of the products of combustion to a degree that will not be injurious to the mechanism of the motor or other propelling device, the mixed products of combustion and vaporizing liquid constituting the motive fluid. Preferably the self-combustible body is burned under pressure, as that due to the gases of its own combustion, the burning heat controlled in such way as to cause the body to burn from a single surface, to the end that uniform production of the gases of combustion may be secured. One effective method of imparting the heat of the products of combustion to the liquid (as water) to be evaporated thereby and mixing the products of combustion and vapor is to cause the products of combustion to heat a body (such for example as fire brick, kaolin, pumice stone or the like) and then utilize the heat of this heated body to evaporate or assist in evaporating the liquid. By finely dividing this heat absorbing body and passing the products of combustion and liquid (in the form of spray or otherwise) between the particles thereof, the desired result is most effectively accomplished. The self combustive body may be burned in a general downward direction while surrounded by a cooling liquid, as water, and the liquid to be evaporated may be fed into the path of the products of combustion in the form of jets or spray.

The feeding of the liquid into the path of the products of combustion may be accomplished in any suitable way, but preferably this is done by subjecting the liquid to pressure due to the products of combustion themselves. When this is done it is desirable to apply the pressure to the liquid in such a way that the pressure per area unit on the liquid exceeds the pressure per area unit in the combustion or atomizing and vaporizing chambers and their connected channels or conduits. This may be accomplished in a variety of ways, as by the employment of differential pistons or pressure surfaces which will serve to augment or increase upon the liquid the pressure, per area unit, due to the products of combustion. The liquid that is thus fed into the path of the products of combustion may be caused to first circulate as a cooling medium around the self-com-

bustible body, thus cooling the self-combustible body and at the same time partially heating the liquid. One very convenient way of accomplishing this is to immerse in the liquid (as water) the body of self-combustible material in such manner that it is compelled to burn downward or at an angle to the horizontal, the liquid by the action of gravity protecting all except the upper surfaces of the self-combustible body from the flame of ignition, and thus compelling the combustion to proceed in the direction of the longitudinal axis of the body.

The inventive idea involved may receive various expressions without losing its identity, and a variety of forms of apparatus may be employed in practicing the process constituting the invention, some of which forms of apparatus are illustrated in the accompanying drawings to assist in the better description of the process.

In said drawings Figure 1 is a longitudinal section of a part of a torpedo, containing apparatus for practicing the process constituting the invention; Fig. 2 is a cross-section on the lines 2, 2, Fig. 1; Fig. 3 is a plane projection of an atomizing or spraying device employed; Fig. 4 is a diagonal cross-section of the same on the line 4, 4, Fig. 3; Fig. 5 is a cross-sectional view of a tube for containing a rod or candle of powder constituting the self-combustive body, a part of the spraying or atomizing device being shown in elevation; Fig. 6 is a longitudinal section of a device for lighting the powder candle, adjacent parts of the torpedo being also shown; Fig. 7 is a cross-sectional view on the line 7, 7, Fig. 6; Fig. 8 is a longitudinal section of a part of a torpedo containing a modified form of apparatus for practicing the invention; Fig. 9 is a cross-sectional view on the line 9, 9, Fig. 8; Fig. 10 is an elevation of a portion of the torpedo showing a door or plate used to close an opening through which the powder candle is inserted into position Fig. 11 is an enlarged cross-section of the powder tube and surrounding jacket tube, showing the liquid-controlling valve; Fig. 12 is a radial section on the line 12 of Fig. 11; Fig. 13 is an enlarged cross-section of another form of valve; Fig. 14 is a longitudinal section of a portion of a torpedo containing a modified form of apparatus; Fig. 15 is an enlarged longitudinal section of the means for automatically igniting the powder candle; Fig. 16 is a view similar to Fig. 14, but showing a modified form of the apparatus illustrated in Fig. 14.

Referring to the drawings, 1 is the torpedo casing which can be made quite light, it being only necessary that it should be strong enough to support the contained apparatus. It is stiffened at its forward end by a partition 2, forming a forward chamber containing the explosive charge 3, and the fuse 4. The powder candle or self-combustible, 5, in the form of apparatus shown in Fig. 1, is contained in a central longitudinal tube 6 which extends from the front of the torpedo to an atomizing or spraying device to be hereinafter described. The tube 6 contains at its forward end the fuse 4, and a portion of the explosive charge 3, a plug 15 separating the candle-containing part of the tube from the charge 3.

The rear end of the candle tube 6, is in communication, through a supporting partition 7, with an atomizing and mixing device, in a chamber 50, consisting of a series of concentric circular passages formed by the cylinders 8 and 9, and the torpedo casing 1, which are closed at their rear ends, and are attached to the partition 7, and contain atomizing material composed of pieces of firebrick, kaolin, pumice stone or other suitable substance, which material is held in the inner cylinder or mixing cylinder 8, between a plurality of transverse perforated metallic partitions 10, covered on their front surfaces with wire gauze or netting 11, for more completely atomizing, disseminating and mixing the liquid spray and products of combustion.

The rear end of the inner cylinder 8 is provided with an opening 12^a into the second cylinder 9, covered with a perforated and gauze-covered plate 12, to prevent the atomizing material from stopping the opening. The second cylinder 9, is also provided with openings 9^a into the outer cylinder or torpedo casing at its forward end and near the partition 7, so that the gases and vapor upon escaping from the candle tube and spraying device, pass longitudinally through the inner cylinder 8, return through the second cylinder 9 and pass rearward again through the outer casing and the end perforated partition 13, to and through the rear partition 13^a, and by means of the pipe 14, to the motive machinery of the torpedo.

The candle 5 is ignited preferably by means of a small rod of a self-combustible material 15^a inserted into the end of the candle and projecting out of the candle tube toward the cylinder 8, where it is in contact with a similar rod 16, extending radially into the combustion chamber from an externally removable plug 17 (see Figs. 1 and 6). The radial rod 16 is ignited by an electric spark or incandescence and is provided for this purpose with two internal insulated wires 18, preferably united at the inner end of the rod by a small filament of platinum or other suitable metal, adapted to be heated to incandescence by the passage of an electric current.

The radial rod is inserted into a removable socket 18^a, through which the wires 18 extend and are sealed therein by means of a body of lead 19, held between two plates 20,

and adapted to be compressed so as to thoroughly pack around the wires by means of the plunger 21 under the pressure of the screw plug 17, the plunger and plug having a central opening for the passage of the insulated wires to the outside of the torpedo. The socket piece 18ª is provided with an annular recess communicating with the main body of lead so that when the plug is tightly screwed down, the lead prevents any escape of gases from the combustion chamber.

The candle tube 6 is surrounded by a jacket tube 21ª leaving an annular space between the tube and jacket for a cooling circulating liquid. Preferably such liquid forms a part of that to be sprayed into the products of combustion, and in such case the annular space referred to is in communication with a reservoir 22, containing the liquid, and at its rear end said annular space communicates with a spraying or atomizing device 23, for injecting the liquid into the products of combustion as they pass from the candle tube 6, as will be hereinafter described.

The reservoir 22 is formed of the tube 21ª combined with a permanent head 24, attached thereto, and a longitudinally sliding outer wall or cylinder 25, attached to the sliding head or piston 26, which head or piston is extended radially outside of the cylinder 25, preferably to the inside of the casing 1. It will be seen, therefore, that the outer surface of the piston is of greater area than that portion of the inner surface forming a part of the liquid-holding reservoir, and that, should the pressures per unit of area be equal on both surfaces, the piston and cylinder will move forward and force the liquid through the jacket tube and to the spraying device. In order to accomplish this result, the outer surface of the piston 26, is placed in communication with the combustion chamber or evaporating chamber 50 by means of the openings 27, through the partition 7, so that, when the powder is ignited and as pressure is generated, the liquid is forced into the gases of combustion. It will be understood that the pressure on the forward surface of the piston outside the reservoir is practically nothing.

The reservoir is provided with a filling tube or pipe 28, adapted to be opened to the outside of the torpedo, and the colloidal candle 5 is supplied or replaced through the front of the torpedo by removing the fuse 4 and plug 15. The part of torpedo casing about the mixing chambers and liquid reservoir is made of thicker material, in order to stand the pressure of the gases of combustion and evaporated liquid.

The spraying or atomizing device illustrated in Figs. 3 to 5, inclusive, consists of a large number of centrally extending and radial nipples, 28ª, positioned in a zig-zag relation to each other, so that the jets of water or other liquid in emitting from the nipples, may enter every portion of the current of the powder gases. The spraying or atomizing device is preferably formed by tapping the stock or candle tube 6 with threads of comparatively great pitch and of such contour in cross-section as to form threads of different heights (see Fig. 4) while another set of threads are cut from the opposite end of the stock, but of a different pitch, so that by the intersection of the two threads, nipples are formed not only of different lengths, but also not in a longitudinal line with each other.

Instead of placing the candle tube and the mixing chamber formed by the cylinders 8 and 9 concentric with the torpedo body, as in Fig. 1, these, if desired, may be arranged as in Fig. 8, in which the candle tube 6ª is shown passing eccentrically through the reservoir and opening into the cylinders 8 and 9, which are not only eccentric to the torpedo body, but are also eccentric to each other. From the reservoir the tube 6ª is curved across the center of the torpedo body to an opening in the side wall, which opening is closed by a removable plate 29, Figs. 8 and 10. The curved form of the candle 6ª does not interfere with the placing of the candle in the tube, since the latter is of plastic or flexible character and readily conforms to the curve of the tube.

In order to prevent the liquid in the reservoir from flowing into the candle tube and combustion chamber, when the candle is not ignited, a spring controlled annular valve 30 (Figs. 11 and 12) of rubber or other suitable material is placed around the candle tube 6, between the communication of the reservoir with the jacket tube 21ª and the spraying or atomizing device 23, and is attached to the jacket tube in any suitable manner, as by a ring and screws 31. The valve is held normally seated against the candle tube 6 by a spring 32 of any suitable form, such as a split ring, Fig. 11, or a coiled spring 32ª, Fig. 13, and held in the socket 33ª, fixed to the outer tube 21ª. By this means the valve effectually prevents flow of water to the sprayer or atomizer, but is readily forced open by the pressure of the liquid in the reservoir when the candle is ignited. The candle is preferably covered or coated with a layer 33, of paraffin, Fig. 11, or a mixture of that material and a suitable resin which may be impregnated in a fabric, before or after placing around the rod of powder.

The modified form of apparatus shown in Fig. 14, illustrates a portion of a torpedo with the combustion chamber and mixing device eccentrically situated, and in communication by an opening or conduit 34, with a chamber 35, containing a plurality of

rods or candles 5 of self-combustible colloid, extending in a direction substantially transverse to the torpedo, and each in a perforated metallic tube 36. In the modification mentioned, the candles are vertical, and the perforations of the tube are so arranged that the water with which the compartment is nearly filled will cover the top surface of the candles to prevent their premature ignition from the products of combustion of another burning candle. This means of maintaining the outer surface of the candle cool prevents any possible ignition, except at the top surface purposely ignited.

The rods may be ignited in any suitable manner, in series or in parallel, that is to say, successively or simultaneously. The method illustrated in Fig. 14, however, shows means for igniting one candle externally by electricity, and by means of a small igniter rod 37, which in turn ignites the surface of the first candle. When the candle first ignited is nearly consumed and the zone of fire approaches the bottom of the tube, the pressure of the gases of combustion forces the small contact button 38, at the side of the tube near its bottom outward against the spring 39, Fig. 15, into contact with an insulated metallic button 40, connected by a wire 41, with the small igniter candle or fuse 37 at the top of the next candle. By this means an electric current is made to traverse through the small igniter rod at the top of the succeeding candle, which is ignited, the circuit being completed by the wire 41ª, and the shell of the torpedo, the current being generated by the batteries 42. Each successive candle is ignited in a similar manner, and each ignition device is preferably supplied with a separate battery. In this modification (Fig. 14), I have shown means whereby liquid carbonic acid, or water impregnated with carbonic acid or other liquefiable gas may be injected or sprayed into the path of the products of combustion, by means of the spraying device. For this purpose, the torpedo is provided with the chamber 43, containing the liquid before-mentioned, and placed in communication with the spraying device by means of a pipe 44, passing through the combustion chamber 35, and controlled by a valve 46, that is normally kept closed by the great pressure within the liquid chamber 43, but is forced open as soon as pressure is generated in the combustion chamber sufficiently great to counterbalance the pressure of the liquid-holding chamber by means of the large difference in area between the inside of the valve and its outer piston-like surface 47, in communication with the combustion chamber.

The modification shown in Fig. 16, illustrates a construction similar to that of Fig. 14, but the candles are inclined to the transverse section of the torpedo, and each is provided with a separate igniting device, 37ª, so that they may, if desired, be ignited simultaneously.

In practicing the process constituting the invention the apparatus hereinbefore described is employed as follows: The self-combustible candle 5 of suitable colloidal powder, and the igniting candles or rods 15ª and 16 being in position, and the reservoir being supplied with a suitable liquid, the rod 16 is ignited by passing an electric current through wires 18, 18, whereupon rod 16 ignites rod or candle 15ª and this in turn ignites the self-combustible candle 5. By coating the candle 5 and the interior of the candle-receiving tube with a suitable cement or adhesive substance, the space between the outer surface of the candle and the walls of the containing tube may be effectively closed or filled, thereby preventing the ignition of the candle except on its exposed end surface. This filling of the space between the candle and its tube may be variously accomplished, as by the use of paraffin mixed with a suitable resin, or by covering the exterior surface of the candle with paper, or a cotton, or other fabric, preferably porous, and then wetting the same with water, so that the space between the candle will be filled with water and the wetted material.

Owing to the presence of the cooling medium around the exterior of the candle 5 it burns a little faster at the center than at its periphery, so that combustion proceeds from a cup-shaped surface, the material around the periphery of the cup being forced tightly against the walls of the inclosing tube and acting as a packing to prevent the flame of ignition from entering between the candle and the tube. This secures combustion from a single surface. The products of combustion issue from the tube 6 into the chamber 50, and pass through the broken fire brick or kaolin in cylinder 8 and thence reversely through cylinder 9, into the space between the latter and the torpedo casing through openings 10 to conduit 14 leading to the engine or propelling apparatus. In passing through the fire brick or kaolin the products of combustion heat the latter very hot. The pressure of the products of combustion in the chamber 50 is exerted upon the rear face of the piston plate 26, and since this face has a greater superficial area than that portion of its front face within the reservoir, the piston plate is advanced against the liquid in the reservoir, carrying with it the cylindrical wall 25, and thus forcing the liquid through the spraying or atomizing device 23, into the path of the products of combustion, by which the sprayed or atomized liquid is instantly heated and vaporized, and carried through the cylinders 8 and 9, where the

vaporization of the liquid is perfected and the products of combustion and vapors are thoroughly mixed, and thence to the conduit 14. It will be seen that the liquid is not only heated by the products of combustion, but that the latter also have their temperature reduced by the liquid. Moreover the circulation of the liquid from the reservoir around the candle tube serves to reduce the temperature of the latter. Furthermore, since the introduction of the liquid into the products of combustion is accomplished by the pressure of such products, it will be readily understood that the amount of liquid thus supplied will be approximately proportional to the pressure of the products of combustion.

What is claimed is:

1. The process of producing a motor fluid, which consists in continuously burning a self-combusting body and continuously forcing a liquid into the products of combustion by pressure of the products of combustion.

2. The process of producing a motor fluid, which consists in continuously burning a self-combusting body under pressure and continuously forcing a liquid into the products of combustion by pressure of the products of combustion.

3. The process of producing a motor fluid, which consists in continuously burning a self-combusting body under pressure, transmitting and augmenting the pressure of the products of combustion per area unit upon a liquid and forcing it into the products of combustion.

4. The process of producing a motor fluid, which consists in burning under pressure a self-combusting material, utilizing heat thereof to heat a body interposed in the path of the products of combustion, and then utilizing the heat of the heated body for evaporating a liquid mixed with the products of combustion.

5. In the production of a motor fluid, the process of burning a self-combustible body from a single surface, and simultaneously subjecting the body to a cooling medium.

6. In the production of a motor fluid, the process of burning a self-combustible body by exposing a single surface to the consuming flame, and simultaneously circulating a cooling medium about the combustible body.

7. In the production of a motor fluid, the process of burning a self-combustible body under pressure, and injecting a liquid into the path of the products of combustion in a direction substantially at right angles to the said path.

8. In the production of a motor fluid, the process of evaporating a liquid, which consists in forcing the liquid into the path of the products of combustion of a burning body in a plurality of independent jets, entering the path from opposite directions.

9. In the production of a motor fluid, the process of evaporating a liquid, which consists in first heating the liquid by the heat of products of combustion of a burning body capable of supporting its own combustion, then injecting the heated liquid into the products of combustion to be evaporated.

10. The process of producing a motor fluid, which consists in immersing in water or other liquid, a body of material capable of supporting its own combustion, in such wise that the body may be ignited and burned from an upper surface, downward in a line vertical to, or at an angle with the horizontal plane, whereby the liquid shall by gravity be maintained around the burning material to prevent it from igniting and being burned in a horizontal direction, or in a direction transverse to the longitudinal axis of the burning body.

11. The process of producing a motor fluid, which consists in burning a body of material capable of supporting its own combustion in a direction downward while the body is surrounded with water.

12. The process of producing a motor fluid, which consists in continuously burning a self-combustible body under pressure of its own products of combustion, and continuously forcing a liquid into said products of combustion by their own pressure.

13. The process of producing a motor fluid, which consists in continuously burning a self-combustible body from a single surface, and continuously forcing a liquid into the products of combustion by their own pressure.

14. The process of producing a motor fluid, which consists in burning a self-combustible body from a single surface, imparting a portion of the generated heat to a liquid separated from the products of combustion, and then forcing said liquid into the products of combustion.

15. The process of producing a motor fluid, which consists in burning a solid self-combustible body under pressure of its own products of combustion, imparting some of the heat thus generated to a liquid, and then spraying said liquid into the products of combustion.

16. The process of producing a motor fluid which consists in burning a solid self combustible body and injecting a heated liquid into the products of combustion.

17. The process of producing a motor fluid which consists in utilizing the pressure of the products of combustion of a self-combustible body to force a liquid into said products of combustion and the heat of said products of combustion to raise the temperature of the liquid.

18. The process of producing a motor fluid which consists in burning a self-combustible body in a closed chamber, causing

the products of combustion to react against the movable wall of a chamber containing a liquid, and thereby forcing said liquid into said products of combustion.

19. The process of producing a motor fluid by burning a solid body containing sufficient oxygen to support its own combustion in a closed chamber, utilizing the heat thereof to evaporate a liquid, and then mixing the products of combustion and the vapors of the liquid to form the motor fluid.

20. The process of producing a motor fluid which consists in burning a solid explosive material in a closed chamber, and then utilizing the pressure of the products of combustion to force a liquid into the presence of the said products, whereby the heat of the products of combustion vaporizes the liquid and the temperature of said products is lowered.

21. The process of producing a motor fluid, which consists in burning an explosive material in a closed chamber having a movable wall, which wall also constitutes one wall of a second chamber containing a fluid, as water, and utilizing the pressure of the products of combustion to actuate said movable wall for forcing the fluid into the chamber containing the products of combustion, whereby the fluid has its temperature raised by the heat of the products of combustion, and the latter have their temperature lowered by the fluid.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

HUDSON MAXIM.

Witnesses:
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Elisha K. Camp.